

Ecological distribution and seasonal change of soil microorganisms in pure and mixed plantations

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Abstract: Soil samples were collected from the surface soil of three kinds of plantations mixed plantation of Dahurian larch and Manchurian ash, pure ash plantation and pure larch plantation, at Maoershan Forest experiment center in Heilongjiang Province. The result of measuring and analysis showed that the number of the bacteria was the most and their effective scope and active strength were the most remarkable comparing with various kinds of soil microorganisms. Actinomyces were the second most and the fungi were the least in number. Numbers of the soil microorganisms in mixed plantation had a more number than that in the pure ash plantation. The number and species of microorganisms were different among different soil layers. For the same kind of soil, the number and species of the microorganisms in the surface layer were the most, and declined with the increase of the soil depth. The seasonal change of the number of the soil microorganisms in pure or mixed plantations was also remarkable. The number of the microorganisms increases obviously with the increase of the atmospheric temperature. The total number of microorganisms in Jan. was 30.0%-40.2% of the number in Sep. Both the vertical distribution and seasonal change being concerned, the number of the soil microorganisms in mixed plantation was on a higher level than that in pure plantation.

Key words: *Fraxinus mandshurica*; *Larix gmelini*; Mixed plantation; Microorganism

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Introduction

Soil microorganisms are important ingredients in soil and obviously affect soil fertility, and they can change the physicochemical properties of the soils by their metabolic activities. The reproduction of microorganisms can intensively influence growth and development of plants. The roots often secrete various kinds of exosmose material such as saccharide, amino acid and vitamins, which can also stimulate the reproduction of the soil microorganisms. The number and species of the soil microorganisms are different with the change of the soil type, environmental conditions, season, species and the development stages of plants.

Manchurian ash (*Fraxinus mandshurica*) and Dahurian larch (*Larix gmelini*) are the important tree species planted in the northeast of China. But the recession phenomenon in pure larch plantation often occurs after a period of growth. After ash and larch are mixed, the gross yield in the mixed plantation is higher than that in their pure ones. The growth of ash in mixed plantation was obviously better than that in pure plantation (Liu 1986). The species and number of the soil microorganisms in the pure and mixed

plantations are studied in this paper, which may help discern growth mechanism of the mixed plantations.

Materials and methods

Soil samples were collected from Laoshan Experiment Station at Maoershan Forest Experiment center in Heilongjiang Province (127°30'-127°34' E, 45°20'-45°25' N), where annual average temperature is 2.8 °C and the annual average rainfall and evaporation capacity is 723.7 mm and 1 093.9 mm respectively. The mixed plantation of Dahurian larch and Manchurian ash was formed because of the natural regeneration of ash in the pure larch plantation. The larch plantation was 11 years old, on an average, 9.5 cm in DBH and 8.3 cm in average height, while the ash was 8 years old, 6.2 cm in DBH and 6.8 cm in height in average. The pure plantations of larch and ash were planted in the same year as the mixed ones. The site conditions of three kinds of plantations were alike and the soil type belongs to albic dark brown forest soil.

In the middle of each month from Jan. to Sep. 1992, 11 soil samples were obtained evenly from the surface soil of every kind of plantation. The sampling depth is from 0 to 30 cm.

Numbers of living bacteria, actinomyces and fungi were measured by the dilution plate-count method (Soil Research Institute in Nanjing 1985). Inoculation was operated by evenly mixed method. Three kinds

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of solid culture media were used. Peptone Medium was used to culture bacterium and Gao No. 1 medium was used to culture actinomyces. Martin's medium was used to culture fungi (Fan 1989).

Results and discussion

Although there were many kinds of microorganisms in the soil, the most important populations were bacteria, actinomyces and fungi, which had different physiological characteristics and actions. The constitution and number of the microbial populations were different because of the different living conditions offered by the different soil in the three kinds of plantations. The number of the bacteria was the most among various kinds of soil microorganisms, which made up 88.9%-89.9% in the total number of the microorganisms as shown in Table 1. The biomass of the bacteria was not great despite of its large number. The bacteria were one of the most active factors in the soil because of its little volume, active metabolism, rapid reproduction and large contact area with soil (Cheng 1990).

Table 1. The number of soil microbe in pure ash, larch plantations and their mixed plantation 10^5 individuals · g⁻¹

Plantation type	Bacteria	Actinomyces	Fungi	Total
Mixed plantation	45	4.8	0.3	50.1
Pure ash plantation	32	3.9	0.1	36.0
Pure larch plantation	41	3.8	0.8	45.6

Note: Soil was dried in the experiment.

The number of actinomyces was the second largest and made up 8.3%-9.5% of total number in the soil under the various kinds of plantations. Although the number of actinomyces was smaller than that of bacteria, its biomass was nearly equal to bacteria's because the volume for the actinomyces for every filamentous vegetative organ was hundreds of times

larger than that of bacteria. The metabolic diversity and growth speed of actinomyces were inferior to that of bacteria and fungi. It is still not clearly understood about the action of the actinomyces to the decomposition of the soil organic matters. It is generally considered that they act like fungi in many aspects. The action of the actenomyces is not obvious during the early stage of the decomposing of the organisms because of its weak competition for nutrient substrate, but during the later stage, actinomyces can play a very important role in decomposing organic matters, especially for some stable materials such as lignine, waxiness and chitin (Cheng 1993).

The fungi are the third most important population for the soil microbe. Its number is fewer than bacterium or actinomyces. The fungi hyphae are several dozens times wider than actinomyces. The fungi are very important in decomposing plant remnants, especially in woody plants because woody plants contain a lot of tannin, which is resistant to bacteria. The action of the fungi in decomposing organic matter is more remarkable than bacteria. The fungi play an important part in the process of the soil maturity because they are relevant to the formation of the soil humus. Its population is unstable to some extent. The fungi reveal an active metabolism and utilize the nutrient substrate rapidly when they are under a suitable condition such as ample organism, adequate water and good aeration. But when the environmental conditions became worse, fungi went into a dormant state and the metabolism almost stopped (Cheng 1993).

Comparison of the total numbers of the soil microorganisms in the three kinds of plantations revealed that the total number of soil microbe in mixed plantation was the largest, the second in pure larch plantation and the lowest in pure ash plantation. The difference of the total number of the soil microbe in various kinds of plantations mainly was results from a synthetic effect of different ecological factors, such as soil properties, ingredients of litter, climatic feature, etc.

Table 2. Vertical distribution of soil microbe in pure and mixed plantations

Type	Depth/cm	Bacteria	Actinomyces	Fungi	10^5 individuals · g ⁻¹
Mixed plantation	10	420.0	25.0	32.0	477.0
	20	200.0	20.0	20.0	240.0
	30	5.5	4.7	3.2	13.4
Pure ash plantation	10	200.0	20.0	15.0	235.0
	20	12.0	15.0	2.5	29.5
	30	4.2	2.5	0.3	7.0
Pure larch plantation	10	400.0	10.0	40.0	450.0
	20	10.0	6.0	15.0	31.0
	30	4.5	5.6	0.1	9.6

Note: Soil was dried in the experiment.

From the Table 2, it was concluded that the number of the microbe in the surface layer was the most in the pure plantations and in the mixed ones, and decreases with the increase of the soil depth. The number of the microbe in soil of 30-cm depth was 2.1%-2.9% of that in 10 cm depth. The number of the soil bacteria, actinomycetes and fungi in the three kinds of plantations was related to the depth of soil. There was an increase in number of bacteria from the surface layer to a 10 cm depth, but the trend was towards a decrease with the further increase of the soil depth. The number of the actinomycetes decreased with the increase of soil depth, but its percentage in the total number of the microbe increased with the increase of the soil depth. For example, the number of actinomycetes in pure ash plantation was 2.0×10^6 individuals in 10-cm depth and the number was 2.5×10^5 individuals in 30 cm depth, but its percentage in the total number of all the microbe increased from 8.5% to 35.7%. This might be because that the actinomycetes were more resistant to the low oxygen and poor environmental conditions (You 1986). Fungi are mainly distributed in the surface

layer of the soil, which is relevant to rich organic matter content and their aerobic characteristics. In short, the number of the microbe in surface layer of soil is the most, which may promote nutrient recycle. The number of the microbe in the subsoil is fewer than that in the surface soil, which may accelerate the mineralization of the soil organic matter.

The soil microbes in different kinds of plantations show its own characteristics in vertical distribution. The number of soil microbes in the pure larch plantation and the mixed plantation of ash and larch decreased sharply with the increase of soil depth, whereas the number of them in the pure ash plantation decreased slowly. But the microbial numbers of the three kinds of plantations were nearly in a same level in the 30 cm depth. From this it could be concluded that there was difference in the species and number for the soil microbe in pure and mixed plantations in the various kinds of litter. The physicochemical properties of soil of the three kinds of plantations tend to the same by the increasing the soil depth and the microbial number was also nearly the same.

Table 3. Seasonal changes of soil microorganisms in pure and mixed plantations

Type	Month	Temperature /°C	Bacteria	Actinomycetes	Fungi	10^5 individuals · g ⁻¹
Mixed plantation	Jan.	-2	95	6.0	15.0	116.0
	May	9	290	7.5	18.0	315.5
	Sep.	16	350	8.5	20.0	378.5
Pure ash	Jan.	-2	32	10.0	1.2	43.2
	May	9	85	17.0	3.5	105.5
	Sep.	16	120	20.0	4.0	144.0
Pure larch	Jan.	-2	110	4.2	24.0	138.2
	May	9	180	7.5	30.0	217.5
	Sep.	16	300	9.2	35.0	344.2

Note: Soil was dried in the experiment.

From Table 3 it can be learned that the seasonal changes of the number of soil microorganisms in the three kinds of plantations are obvious. There were fewer microorganisms in the soil in winter because of the low soil temperature. The number of the microorganism increased obviously in spring with the increase of temperature. In autumn, the number of soil microorganisms reached the peak because of the suitable temperature and the rapid increased of the organic remnants. The number of the soil microbe in Jan. was 30.0% -40.2% of that in Sep.

The seasonal changes of the soil microorganisms are consistent with the growth and development of the trees. The state and the number of soil organic matter change a lot during a year, which obviously affects the nutrient conditions of microbe.

In a word, the number of soil microbe in mixed plantation is always on a high level and is higher than that in pure ash or in larch plantations.

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